# AN ASSESSMENT OF PESTICIDE RESEARCH PROJECTS

**Funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee**

1977 - 1978

Ontario
Ministry of the Environment

The Honourable
George R. McCague,
Minister

K.H. Sharpe,
Deputy Minister

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Executive Secretary to the Committee

* Resigned December 1977

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# RESEARCH PROJECTS FUNDED THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE

## 1977-78

## I. SUMMARY

1) In 1977-78 the Ontario Pesticides Advisory Committee continued a program, first established in 1973, for funding research on pesticides. The objectives of the program are:

   a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

   b) To determine potential environmental hazards with pesticides currently in use.

   c) To reduce pesticide input into the environment.

2) Thirty-seven applications for research support, totalling $444,123 were received.

3) Twenty research projects were funded with a total value of $195,940. The average grant was $9,797 with a range of $3,400 to $42,840.

4) Four grants totalling $60,840 were awarded for studies on development of alternative pesticides for pest control.

5) Ten grants totalling $77,900 were allocated to studies on the persistence and fate of pesticides in the environment and on potential environmental hazards to non-target organisms.

6) Six grants totalling $57,200 were allocated for studies aimed at reducing pesticide input into the environment without loss of effective pest control.

7) The Pesticides Advisory Committee is very satisfied with research progress made in 1977-78 and in preceding years. It recognizes that with the limited funds available the program of grants can be expected only to act as a catalyst in stimulating research in the broad areas indicated in the Committee's Guidelines and for which there is still an urgent requirement.

## II. RECOMMENDATIONS

The Pesticides Advisory Committee recommends that:

1) The Ministry of the Environment continue to support research programs directed toward development of pest control programs which will not pose any serious environmental hazard.

2) The program continue to be supervised by the Pesticides Advisory Committee following the guidelines which have been developed.

## III. REVIEW OF THE RESEARCH PROGRAM

In 1973 the Ministry of the Environment allocated funds to the Ontario Pesticides Advisory Committee to sponsor pesticide research. Results obtained to date (OPAC, 1974, 1975, 1976, 1977) have encouraged the committee to recommend that the research program be continued under its supervision. The committee is gratified that these recommendations have been accepted and that the Ministry increased the research budget to $200,000 in 1977-78.

Initially the Advisory Committee developed terms of reference to govern the awarding of research grants based on three objectives, i.e. the need to find suitable replacements for pesticides deemed hazardous and restricted in use in Ontario; the need to determine if pesticides presently in use pose any serious environmental hazard; and the need to develop more effective approaches to pest control leading to a reduction in pesticide input into the environment. The "Application for Research Support" (Appendix I) based on these objectives, invited proposals for studies on: 1) development, leading to registration of environmentally acceptable pesticides, especially for control of biting flies and pests of agricultural crops (Objective 1); 2) the persistence, fate, and biological significance of pesticides in the environment, including development of information on time which should elapse between dates of treatment and reentry into treated areas and on exposure of agricultural workers to pesticides (Objective 2); and 3) economics of pest control including economic threshold levels of pests, reduction of pesticide use through development of effective pest monitoring and pesticide application techniques, and alternative integrated or non-chemical methods of control (Objective 3). Invitations for applications for research support were distributed in January, 1977 to personnel in Ontario universities, industry, and government (copies of the mailing list are available on request), with the deadline for applications being February 28, 1977.

Thirty-seven proposals totalling $444,123 were received. Thirty-six were from universities (Guelph - 16, Waterloo - 6, Western Ontario - 5, York - 3, Toronto - 3, Brock - 1, Queens - 1, Lakehead - 1). One application was received from industry. (A list of titles of research proposals submitted to the Pesticides Advisory Committee for consideration in 1977-78 is available on request).

Applications were first considered by the Research Subcommittee (Mr. P. D. Foley and Drs. C. D. Fowle, R. Frank, D. N. Huntley, F. L. McEwen, A. J. McGinnis, G. R. Stephenson, and C. R. Harris (Chairman)), and then by the Advisory Committee. Twenty proposals were accepted (Appendix II) valued at $195,940. The average value of each grant was $9,797 ($3,400 - $42,840). Nineteen grants were awarded to universities (Guelph - 8, Western Ontario - 5, York - 2, Waterloo - 2, Toronto - 1, Brock - 1) and one to an agricultural chemical company.

Direction and progress of the research program were monitored by the Advisory Committee in several ways. Initially several applicants were asked to modify their proposals to better meet committee objectives. Recipients of one of the major grants were asked to meet with the committee to review their earlier progress and proposals for 1977-78. Informal contacts between the research subcommittee and some recipients of grants were established during the year. Recipients of grants were asked to provide a progress report (Abstract) by December 31, 1977. These are included in this report (Appendix III). In January 1978, the Advisory Committee sponsored a two-day meeting at which recipients of grants presented reports of their progress. This meeting, held each year for the past few years, has been most successful. It enables members of the Advisory Committee to meet the scientists involved, assess their work, and make constructive suggestions. The scientists are equally enthusiastic, as the meeting presents them with an opportunity to present results of their research and to meet others with similar research interests. Attendance at the meeting is not restricted to recipients of grants and Advisory Committee members. Invitations to attend are sent to university, government, and industry personnel known to be interested in pesticide research. Over 100 people attended the meeting in 1978. Published research reports, thesis, etc. relating to work supported by the Advisory Committee are listed in Appendix IV.

Progress made in 1977-78 relative to the objectives of the program may be summarized as follows:

Objective 1: To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

In recent years environmental concerns have resulted in restrictions on use of some agricultural chemicals in Ontario, e.g. organochlorine and mercurial pesticides. In most instances alternative chemicals were available for use. In a few cases control measures were unsatisfactory or non-existent and the Advisory Committee has funded research aimed at developing suitable control methods. Four grants totalling $60,840 were related to this objective. A fifth study ($4,000) begun the previous year at the request of the Advisory Committee was completed in 1977.

In studies on mosquito control and biology: 1) the susceptibility of important mosquitoes to temephos was determined to establish baselines for future monitoring for development of resistance; 2) several insecticides were evaluated as adulticides with two compounds giving excellent mosquito control; 3) several insecticides were evaluated as larvicides with some giving good control; 4) insect electrocutors did not give appreciable protection from mosquito bites; 5) studies were initiated on the biology of Coquillettidia perturbans to determine nuisance studies and optimal time for adulticiding (10)*. Another study on biting flies to investigate the effects of insect growth regulators on emergence of black fly larvae and on non-target aquatic invertebrates was supported (12). Results from this study will be reported in 1979.

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* Numbers in brackets refer to Abstracts of projects reported in Appendix III.

With restrictions on the use of organochlorine insecticides control measures for cutworms attacking agricultural crops were inadequate. Research sponsored, in part, by the Advisory Committee between 1970-76 resulted in registration of leptophos and chlorpyrifos for cutworm control. The use of leptophos in Canada was banned in 1977. Chlorpyrifos was registered on only a few crops. Two studies to investigate the feasibility of developing compounds from a new group of chemicals, the pyrethroids, for cutworm control were supported. Efficacy studies indicated that several pyrethroids were effective at very low rates of application against several important cutworm species (8, 21). Partly as a result of this work, one pyrethroid insecticide was registered for use in 1978 for control of cutworms attacking tobacco.

While environmental contamination resulting from agricultural use of mercurial compounds in Ontario is minimal when compared to industrial mercury pollution, mercurial pesticides have been replaced wherever feasible. Some mercurial fungicides are still used, e.g. on golf courses. Late in 1978 a proposal to evaluate the efficacy of some non-mercurial experimental fungicides for control of snow mold on fine turf grass was supported (7). Results of this study will be reported in 1979.

Objective 2: To determine potential environmental hazards with pesticides presently in use.

Ten grants totalling $77,900 were allocated to this objective.

Restrictions on the use of organochlorine insecticides are resulting in a decline in residues of these compounds in the environment in Ontario. Residues of organophosphorus insecticides, the main group of chemicals replacing the organochlorine insecticides, are not accumulating to any significant extent in mineral soils. However, recent research, sponsored by the Advisory Committee has demonstrated that residues of organophosphorus insecticides are present at fairly high levels in all major organic soil areas used for vegetable production in Ontario. Carbamate insecticides are also used to control insects attacking crops grown on organic soils. A survey was initiated in the fall of 1977 to determine if residues of this group of insecticides are accumulating in organic soils (17). Results will be reported in 1979.

Organophosphorus insecticides are occurring in organic soils primarily as a result of measures taken to control the onion maggot. For this reason the Pesticides Advisory Committee has been encouraging research: on development of alternative insecticides which are less persistent than ethion which has become the major pesticide residue in organic soils where onions are grown; on development of a pest monitoring technique to reduce the number of insecticide treatments applied; and on non-chemical methods of control. In the first instance, greenhouse studies indicated that, in addition to ethion,

furrow granular treatments of fonofos, fensulfothion, carbofuran, and chlorpyrifos provided effective control of a susceptible onion maggot strain for 10 weeks. Carbofuran and fensulfothion were less persistent in the organic soil than the other three insecticides. Movement of the insecticides outside the immediate area of treatment was minimal (2). In field studies where granular furrow treatments were applied for onion maggot or carrot rust fly control, ethion was most persistent > fonofos > carbofuran (17). The persistence and degradation of some pyrethroid insecticides in soil was investigated. Laboratory tests indicated that they were moderately persistent. Under field conditions they degraded more rapidly than expected on the basis of the laboratory results (2).

Herbicides are used extensively for weed control on organic soil and a study was initiated to determine if residues of some herbicides were persisting in organic soils. Significant residues of linuron and chlorbromuron were detected one year after treatment. After two years neither herbicide was detected in soil at significant levels when applied at normal field applications rates (15).

Environmental studies on fungicides have been hampered by lack of sensitive analytical procedures. Continued emphasis was placed on development of a reliable analytical procedure for benomyl and its degradation product, MBC. Benomyl content and stability in formulations was determined. High pressure liquid chromatography showed promise as a means of determining benomyl and MBC residues in plant extracts (3).

Organochlorine insecticides had the potential to cause drastic effects on non-target terrestrial and aquatic organisms. Less is known as to potential environmental side-effects of other pesticides and for several years the Pesticides Advisory Committee has been encouraging research in this area. The effect of several pyrethroid insecticides on soil microbial populations and activities was investigated. Minor effects were noted but these were transitory in nature. Soil microbial respiration increased in proportion to the concentration of insecticide in soil, suggesting that the pyrethroid insecticides are degraded by soil microorganisms (20). The low water solubilities of the pyrethroid insecticides and high partition coefficients suggested that, if they were relatively stable they might have the potential to bioaccumulate, as occurred with DDT. In laboratory studies no dramatic bioaccumulation occurred with any of four pyrethroids or DDT in three terrestrial food chains. Aquatic food chain bioaccumulation studies are in progress (4). Research on development of a technique for assessing overall, rather than specific effects of pesticide treatments on soil processes (such as litter decomposition) was supported. This technique involves burying nylon fabric bags of various mesh sizes containing leaf "litter" in soil. Depending on mesh size of the bags different soil organisms involved in degradation processes can be excluded. Preliminary results suggested that this technique may provide a useful index for measuring pesticide effects on important soil processes (19).

Several studies were conducted to assess the potential side-effects of pesticides on non-target aquatic organisms. Previous research supported by the Advisory Committee showed that, in small ponds, algal blooms frequently developed after application of the mosquito larvicides, chlorpyrifos and temephos. Application of these insecticides at practical rates of application reduced zooplankton, leading to the hypothesis that zooplankton destruction results in release of nutrients, chiefly phosphorus, which stimulate algal growth. In field tests algal blooms occurred in both treated and untreated ponds, but were larger and more persistent in the latter. Phosphorus in the ponds controlled biomass production. Laboratory studies to clarify the relationship between zooplankton mortality and phosphorus levels are in progress (1). A study was also conducted to assess the effects of aquatic herbicides on the behaviour of fish. Using three different parameters of rheotropic response (reaction to water currents), effects of several aquatic herbicides on rainbow trout were measured. Some of the herbicides, usually at higher concentrations, affected one or more of the parameters tested (5).

The extensive use of organophosphorus insecticides on vegetable crops grown on organic soil and the resulting residues being detected in soil, water, and air in these areas raised the question as to whether the health of humans working or living in such an environment would be affected. Results reported in 1976-77 indicated that some growers/workers/packers in the Holland Marsh were being overexposed to organophosphorus insecticide residues during the growing season. The effects were transitory and cholinesterase activity returned to normal when exposure ceased. In 1978 further research was supported to determine if neuromuscular function of workers exposed to organophosphorus insecticides is being affected. Comparisons will be made between two groups of pesticide applicators exposed to pesticides and an unexposed control group. Results will be reported in 1979 (18).

Objective 3: To reduce total pesticide input into the environment.

The most practical solution to any environmental problem is to reduce input of the contaminant into the environment. One simple way of achieving this goal is to forbid the use of a chemical which may become a serious environmental contaminant. The pesticide problem is more complex. A pesticide is deliberately introduced into the environment to control a specific pest or group of pests. Control of many pests attacking agricultural crops, forests, or man and his animals is essential. Current and future pest control programs are and will be, heavily dependent on the use of chemicals. However, it should be possible, through modification of these programs to utilize pesticides in such a manner that less chemical will be required while still achieving as or more effective control. The Pesticides Advisory Committee considers this to be the major goal of the research program and supported six research projects valued at $57,200 in 1977-78.

Pesticides are often applied as "insurance treatments", i.e. the grower is not sure that the pest will be present but cannot afford the risk that it will occur. Often treatment is not required since the pest will occur at a low level and would not cause serious damage. It is thus important to determine economic thresholds of damage below which pesticide applications would be unnecessary. The cereal leaf beetle was discovered in Ontario more than a decade ago and has now spread as far east as Quebec and north close to Sault Ste. Marie. Initially it was expected that large scale use of insecticides would be required to prevent serious crop damage in Ontario. However research supported by the Advisory Committee over the past few years has established: 1) economic thresholds of damage below which insecticide applications are unnecessary; 2) that, in general, cereal leaf beetle populations are at levels below the economic thresholds; 3) that a parasite which has become established in Ontario is primarily responsible for the low cereal leaf beetle populations encountered in the last few years; and 4) that the parasite continues to work effectively even when host populations are low. No immediate resurgence of the pest is expected and chemical control measures should not be required except in rare instances in isolated fields. No insecticide applications were required in Ontario in 1977 (6).

Development of effective pest monitoring techniques would result in a marked reduction in pesticide input into the environment, i.e. with pesticide applications timed to appearance of the pest there would be no requirement for "insurance" applications. The Advisory Committee supported four studies related to development of pest monitoring programs in 1977-78. The apple maggot is of major economic importance in Ontario. Eleven candidate compounds were synthesized for assessment as sex attractants for apple maggot. Field tests indicated that two compounds attracted apple maggot adults (but did not act as sex attractants). One of the compounds synthesized was very attractive to adults of the spotted tentiform leaf miner (14, 15). Work was also continued on development of a technique for monitoring emergence of onion maggot adults. The day/degree technique was used to predict adult emergence with a minimum of error allowing for better timing and a significant reduction in the number of adulticide sprays (16). A similar approach to reducing the number of fungicide sprays applied to carrots and onions has been supported for several years. Earlier results indicated that with normal weather conditions the number of fungicide sprays can be reduced significantly by timing sprays relative to weather conditions rather than following a regular spray program. In 1977, precipitation in August and September was 150 to 200% of normal. Under such wet conditions the weather-timed schedule was little different than that used in a regular program (9).

Pesticide application techniques are crude and only a small fraction of the pesticide applied actually reaches the target. More efficient application techniques would result in better pest control with less environmental contamination. A study has been funded for several years to assess the feasibility of designing an electrostatic sprayer. In 1977 field tests were conducted in a large commercial orchard in southwestern Ontario. The electrostatic sprayer gave improved leaf coverage resulting in a 30% reduction in spray material applied while still achieving satisfactory fruit quality. Over a five year period a full scale electrostatic orchard sprayer was designed, modified, and field tested to a stage where further development can be considered by manufacturers of such equipment (11).

Alternative non-chemical methods of control may represent the ideal approach to reducing pesticide input into the environment in a few instances. Research on development of an integrated control technique for the onion maggot was continued in 1977-78. This procedure involves use of an insecticide for control of first generation maggot, followed by releases of chemosterilized adults for second and third generation control. In 1977 larval damage in untreated plots was very high with approximately 60% of the crop being destroyed. Where the integrated control program was used maggot damage was insignificant, with control being as good as in fields where numerous chemical adulticide sprays were applied (16).

## ASSESSMENT

The pesticide research program sponsored by the Ministry of the Environment was begun five years ago. Since then $700,000 has been budgeted for pesticide research, of which the Pesticides Advisory Committee allocated $678,489. After five years of operation, it is appropriate to evaluate the progress to date and to consider the future of the program.

The Ministry of the Environment has wisely allowed the Pesticides Advisory Committee latitude in administering the research program. This has enabled the committee to locate, support, and cooperate with scientists genuinely interested in pesticide research and to process applications quickly with a minimum of the red tape and paperwork characteristic of so many granting agencies. Nevertheless, the annual research meeting and assessment of the pesticide research program insure that recipients of grants are accountable for the funds received. The administration procedures and reporting system also insure that operation and progress of the research program are open to public scrutiny. It is the feeling of the Pesticides Advisory Committee that the manner in which the program is being administered is satisfactory.

The Advisory Committee feels that the research done has generally been of high quality. Research accomplishments are not always obvious in a term as short as five years, but a number of accomplishments of the research program are apparent. Several of the immediate problems falling under our first objective have been solved. For example, alternative insecticides have been developed to replace the organochlorine insecticides for tarnished plant bug, flea beetle, and cutworm control. The Pesticides Advisory Committee foresaw the seriousness of the biting fly situation in Ontario and had already funded a comprehensive review of the biting fly problem prior to the outbreak of encephalitis in 1975. This review aided the Ministry of the Environment in organizing, in cooperation with the Ministry of Health, an effective mosquito abatement program in Ontario. The Ministry of the Environment also accepted the recommendation that a biting fly research program be funded at the University of Guelph. In 1977 responsibility for overseeing that research program was assigned to the Pesticides Advisory Committee as part of the pesticide research program. Development of management techniques for biting flies in Ontario will be a long term goal, but progress is being made in understanding their biology and in development of effective control measures. In the longer term other insect control problems will undoubtedly appear as a result of the decision to restrict the use of organochlorine insecticides. Residues of these insecticides are declining in agricultural soils, and as shown in research on the crucifer flea beetle, once these residues decline below biologically active levels in soils, soil insect populations such as flea beetles, wireworms, and white grubs may increase. It will be necessary to cope with these problems as they arise.

Good progress has been made under the second objective in defining the fate and persistence of pesticides in the environment. Studies, supported in part by the Pesticides Advisory Committee, indicate that residues of the organochlorine insecticides are declining in agricultural soils in Ontario and that residues of organophosphorus insecticides are not accumulating in mineral soils to any significant extent. It has been demonstrated that both insecticides and herbicides are more persistent in soils high in organic matter. The discovery that organophosphorus insecticides are accumulating to fairly high levels in organic soils is of concern. In the Holland Marsh, for example, soil, air, and water all contain detectable levels of residues and there is evidence that workers are being overexposed to organophosphorus insecticides. These residues are due primarily to measures taken to control the onion maggot and, to a lesser extent, the carrot rust fly. For this reason the Advisory Committee has given priority to sponsoring research on development of modified chemical or non-chemical methods of onion maggot control. Under this objective research has also been supported for several years to define potential side effects of pesticides currently in use on non-target soil and aquatic organisms. The results indicate that, in general, the effects of residues of most pesticides currently recommended in Ontario on non-target soil and aquatic organisms will be transitory.

As noted earlier the Advisory Committee feels that priority should be assigned to the third goal of reducing pesticide input into the environment while still achieving as or more effective pest control. One very effective approach would be to develop pest monitoring techniques enabling replacement of "insurance applications" with sprays closely timed to the appearance of the pest(s). Research on development of such programs has been promising. The Advisory Committee supported development of the pest monitoring program, now operational, on apples. Research on reducing fungicide use on carrots and onions by scheduling sprays in relation to weather conditions is well advanced, as is development of a pest monitoring technique for the onion maggot.

A point of major concern to both the research scientists involved and the Pesticides Advisory Committee is that implementation of these pest monitoring programs is being delayed by lack of adequate manpower and financial support in the responsible agencies. More effective application techniques also would reduce the amount of pesticide required. Two programs have provided encouraging results: one study showed that addition of some adjuvants reduces spray drift significantly; the second study suggested that development of an electrostatic sprayer for agricultural uses may be feasible. The use of electrostatically charged sprays results in deposition of a higher percentage of the spray droplets on the target. Development of information on economic thresholds of damage below which pesticide applications will be unnecessary and on alternative approaches to pest control represent the long term solution. Research conducted on the cereal leaf beetle demonstrates the feasibility of this approach. Originally it was expected that widespread chemical control of this pest would be necessary. However, determination of population levels which crops could tolerate without significant reduction in yield indicated that only limited spraying would be necessary. Development of a naturally occurring parasite appears to be holding the cereal leaf population below threshold levels. Thus the need for application of chemicals is expected to be minimal.

The program on integrated control of the onion maggot shows similar promise. However, difficulties being encountered in developing the sterile male technique as one component of the integrated program demonstrate the complexity of developing such programs. Assuming research in development of pest monitoring techniques and integrated control programs is successful, some formula for financing and implementing these programs is essential. Agencies espousing pest management must be willing to provide the funds and manpower required for implementation. If they do not, scientists currently interested in this type of research will, through sheer frustration, apply their energy and ability in other areas.

An additional benefit over the past five years of the research program, is that a number of graduate students have been able to obtain excellent training relating to the management and environmental impact of pesticides. Without such support most would have branched out into other areas and disciplines.

The Pesticides Advisory Committee is pleased with the research progress made in the past five years and recommends continuation of the program. Part of the success of the program is due to the fact that it has deliberately been kept small allowing committee members, all of whom have other full-time responsibilities, to administer it with a minimum of effort. The Committee feels that this approach should be maintained. In doing so, it recognizes that with limited funds available, the program can be expected only to act as a catalyst in stimulating research in the broad areas indicated in the guidelines, for which there is still an urgent requirement.

## IV. REFERENCES CITED

Ontario Pesticides Advisory Committee. 1974. An assessment of research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1973-74. 33p.

1975. An assessment of research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1974-75. 36 p.

1976. An assessment of research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1975-76. 42 p.

1977. An assessment of research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1976-77. 40 p.

APPENDIX I. Format of advertisement inviting applications for research support from the Ontario Pesticides Advisory Committee, 1977-78

## APPLICATION FOR RESEARCH SUPPORT

The Ontario Ministry of the Environment has a limited amount of funds available for 1978 to sponsor research aimed at: 1) determining potential environmental hazards associated with pesticides currently in use: 2) developing alternative pesticides for those deemed environmentally hazardous and thus restricted in use; and 3) developing alternative approaches to pest control in order to reduce total pesticide input into the environment. Preference will be given to proposals yielding results in a relatively short time with funds being committed on a yearly basis. Research should be in the context of normal use patterns.

The Ministry invites research proposals in the following areas:

1. Economics of pest control including economic threshold levels of pests.

2. Studies leading to registration of environmentally acceptable pesticides especially for control of biting flies and pests of agricultural crops.

3. Reduction of pesticide use through development of effective pest monitoring techniques; alternative integrated or non-chemical methods of control; or improved application techniques.

4. Studies on the persistence, fate, and biological significance of pesticides in the environment, with particular reference to pesticides widely used in Ontario.

5. Development of information on time which should elapse between dates of treatment and re-entry into treated areas, and on exposure of agricultural workers to pesticides.

## APPLICATION PROCEDURE

Research proposals should be submitted to:

The Chairman, Pesticides Advisory Committee
Ontario Ministry of the Environment
5th floor, Mowat Block
Queen's Park
TORONTO, Ontario M7A 1A2

Applications should include the following:

1. Title of project
2. Name, address and affiliation of applicant(s)
3. Discussion of problem (Applicants applying for continuation of a grant should include a summary of previous progress)
4. Clear statement of objective(s)
5. Plan for program
6. Facilities available
7. Budget - categorize costs as: Personnel - full time and part time, equipment, supplies, overhead costs, other
8. Listing of current projects and other sources of funding
9. Curriculum vitae on principal investigator(s) (if not already on file with the Pesticides Advisory Committee).

Applications should be received by February 28, 1977.

APPENDIX II. Research projects supported by the Ontario Pesticides Advisory Committee, 1977-78

| No. | Applicant | Location | Project Title | Amount Granted |
|---|---|---|---|---|
| 1. | Boyer, M. G.<br>Fowle, C. D. | York University | The responses of bacteria, algae and invertebrates in small ponds to applications of mosquito larvicides | $ 3,300. |
| 2. | Chapman, R. A.<br>Svec, H. J.<br>Spencer, E. Y. | University of Western Ontario | Activity and persistence of some organo-phosphorus, carbamate, and pyrethroid insecticides in soil | 10,900. |
| 3. | Chiba, M. | Brock University | Further development of an analytical method for benomyl residues in agricultural commodities and studies on the persistence of benomyl after spray application in the environment | 3,500. |
| 4. | Coats, J. R. | University of Guelph | Evaluation of the toxicity, degradability, and bioaccumulation potential of pyrethroid insecticides. | 8,300. |
| 5. | Dodson, J. J.<br>Mayfield, C. I. | University of Waterloo | The effects of sublethal doses of diquat, simazine, glyphosate and 2,4-D-butoxyethanol ester on the rheotropic response of rainbow trout | 6,000 |
| 6. | Ellis, C. R. | University of Guelph | The economic threshold of cereal leaf beetle Oulema melanopus (Linnaeus) on oats and barley in Ontario | 8,000. |
| 7. | Fushtey, S. G. | University of Guelph | Efficacy of fungicides for the control of snow mold in fine turf grass | 4,000. |
| 8. | Johnson, E. F.<br>* Gardiner, R. P. | Chipman Chemicals | Control of darksided cutworm, Euxoa messoria (Harris) in southwestern Ontario tobacco fields with permethrin (NRDC 143) insecticide. | 8,000. |

* deceased

APPENDIX II cont'd.....

| No. | Applicant | Location | Project Title | Amount Granted |
|---|---|---|---|---|
| 9. | Gillespie, T. J.<br>Sutton, J. C. | University of Guelph | Reduction of fungicide usage on vegetable crops by timing fungicide applications according to weather data | 9,800. |
| 10. | Helson, B. V.<br>Surgeoner, G. A. | University of Guelph | Research on the control of biting flies, especially mosquitoes, in Ontario | 42,840. |
| 11. | Inculet, I. I.<br>Castle, G. S. P.<br>Kelly, C. B. | University of Western Ontario | Electrostatic application of pesticides in orchards and field crops | 3,400. |
| 12. | Kaushik, N. K. | University of Guelph | Effects of insect growth regulators on emergence of black fly larvae and on non-target aquatic invertebrates | 6,000. |
| 13. | Laing, J. E. | University of Guelph | Development of monitoring techniques for the apple maggot | 8,000. |
| 14. | Leznoff, C. C. | York University | The chemical synthesis of candidate sex attractants for the apple maggot | 8,000. |
| 15. | Mayfield, C. I. | University of Waterloo | Herbicide residues in organic soils following the use of linuron and chlorbromuron | 4,700. |
| 16. | McEwen, F. L. | University of Guelph | Control of the onion maggot, Hylemya antiqua (Meigen) by use of the sterile male technique | 20,000. |
| 17. | Miles, J. R. W.<br>Spencer, E. Y. | University of Western Ontario | Accumulation of residues of carbamate insecticides in organic soils in Ontario | 8,000. |
| 18. | Stopps, G. J.<br>*Brown, J. R.<br>Alcock, V. | University of Toronto | Neuro-muscular function in persons exposed to organophosphorus pesticides compared with an unexposed control group | 18,000. |

* deceased

APPENDIX II cont'd....

| No. | Applicant | Location | Project Title | Amount Granted |
|---|---|---|---|---|
| 19. | Tomlin, A. D.<br>Spencer, E. Y. | University of Western Ontario | Feasibility of using the litterbag technique as an index of the environmental impact of soil insecticides on the soil fauna | 8,000 |
| 20. | Tu, C. M.<br>Spencer, E. Y. | University of Western Ontario | Effects of pyrethroid insecticides on microbial populations and activities in soil | 7,200. |
| | | | TOTAL | $ 195,940. |

APPENDIX III. Progress reports (Abstracts) on projects funded by the Ontario Pesticides Advisory Committee, 1977-78.

1. Boyer, M. G., Fowle. C. D., and Hebda, A. - The responses of bacteria, algae, and invertebrates in small ponds to applications of mosquito larvicides.

Previous work at York University, as well as studies reported in the literature, has shown that treatments of small pond ecosystems with chlorpyrifos and temephos are frequently followed by algal blooms. The time of appearance appears to be a function of several possible factors including availability of nutrients, selective reduction of grazing zooplankton, and mobilization of limiting nutrients not usually available.

Studies by Michael Papst and Donald Hughes in our group have shown that these pesticides do selectively reduce zooplankton and that the rate of recovery varies among species. Papst has been investigating the possibility that reduced grazing pressure may somehow encourage algal blooms.

The present study is an investigation of another possibility; namely, that the destruction of zooplankton releases nutrients, chiefly phosphorous, which stimulate growth of algae.

In the summer of 1977, field experiments were carried out in our plastic-lined artificial ponds at York University and are presently being followed up in aquaria in the laboratory. Field trials designed to allow us to monitor phosphorous were set up in which we treated ponds with 10 ppb chlorpyrifos-methyl and chlorpyrifos and followed the changes in phosphorous and some other chemical parameters 10-12 weeks after treatment.

At first we encountered a number of difficulties with the standard methods for analyzing for phosphorous. These included technical problems in the method which, if not closely examined, may easily be overlooked and produce misleading results. We also found that the heavy rains experienced during the summer caused turbulence in the ponds which mixed unusual amounts of nutrient from the bottom into the water column and masked effects which may have followed the pesticide application.

Although both treated and control ponds produced algal blooms, those in treated ponds were more massive and persistent than in controls. A single experiment on rate of turnover using radioactive phosphorous, carried out in cooperation with Dr. D. R. Lean (Canada Centre for Inland Waters), showed that phosphorous in our ponds was in demand and was indeed controlling biomass production.

We still do not know what contribution dead zooplankton make to changes in phosphorous but we are now following this up in a series of experiments in aquaria in the laboratory. Additional field experiments are planned for 1978 as well as some monitoring of the phosphorous cycle using radioactive phosphorous.

2. Chapman, R. A. and Svec, H. J. - Activity and persistence of some organophosphorus, carbamate and pyrethroid insecticides in soil.

A greenhouse bioassay procedure suitable for assessing the efficacy of furrow treatments of granular insecticide/fungicide combinations against onion maggot was developed. At currently recommended rates, ethion, fonofos, fensulfothion, carbofuran and chlorpyrifos provided effective control of a susceptible onion maggot strain over the 10 week period studied. Varying the amount of water applied from ½" to 1½" did not change their effectiveness. The concentrations of insecticides in the furrow, beside the furrow and in the leaching water were determined periodically over the 10 weeks. Only traces of insecticide were leached from the soil even with the largest watering. Migration of the insecticide into the soil outside the furrow was minimal as was the migration downward in the furrow. The concentrations of ethion, fonofos and chlorpyrifos in the furrow decreased slowly over the sampling period with losses in general less than 50% with no effect due to the amount of water applied observable. The concentrations of carbofuran and fensulfothion decreased much more rapidly and reached the lowest concentrations, ca. 10-20% of the applied dose, in the samples receiving the larger amounts of water. At least two insecticides remain to be investigated. Field studies have been set up to examine the uptake of the insecticides by onions and the carryover of the insecticides in the soil from year to year over a 3 year period. No data is available on this experiment yet.

The chemical and biological activity of four pyrethroid insecticides in sand was studied over 48 weeks in the laboratory and compared with that of chlorpyrifos, carbofuran and dieldrin. At the levels used, 4 x the $LD_{50}$ for crickets (7-15 ppm), the biological activity and the pyrethroids disappeared at a rate similar to carbofuran and much slower than chlorpyrifos. Various sterio- and geometric isomers present were observed to disappear at different rates and this is being examined further to determine the specific isomers involved. Field studies on the persistence of broadcast applications cf 4 oz./acre incorporated into sand and muck soil were also carried out. From the low initial concentrations produced by this treatment, the pyrethroids disappeared more rapidly than they did in the lab study. As has been observed previously with other insecticides, the rate of disappearance from muck was slower than from sand. Residues in carrots and radishes grown in the soils were <0.01 ppm.

3. Chiba, M. - Further development of an analytical method for benomyl residues in agricultural communities and studies on persistence of benomyl after spray application in the environment.

The rapid spectrophotometric method developed by the author has been further developed to determine benomyl and MBC simultaneously in wettable powder formulations.

Analyses were conducted on Benlate(R) 50% WP and Benlate(R) 10% WP mixed with Captan 50%. All ingredients are solubilized in a special solvent mixture consisting of chloroform, dioxane, and water. This solvent mixture was prepared at room temperature and cooled to 1°C.

A sample weighing 100 mg (for 50% WP) and 500 mg (for 10% WP) was placed in a 200 ml volumetric flask and dissolved in the 1°C solvent mixture.

Degradation of benomyl, unavoidable at 25°C, was eliminated at this cold temperature. Absorbance of the diluted solution was measured at 294 and 286 nm in a spectrophotometer and individual concentrations of benomyl and MBC were calculated from a simple equation. To stabilize benomyl in standard solutions and to reform benomyl from MBC, n-butyl isocyanate was utilized.

Most 50% WP formulations contained 50-55% intact benomyl and 0.4-2.3% MBC. Benomyl was stable in all the WP formulations although both time and conditions of storage varied significantly. Most 10% WP samples contained 8-12% benomyl and 0.1-2.9% MBC. Degradation of benomyl to MBC in these formulations, however, seemed to be faster than in 50% WP formulations; in some samples more than 70% of the ingredient was present as MBC after 10 months storage.

Kinetics of the reversible conversion of benomyl to MBC and n-butyl isocyanate in organic solvents were investigated. Values of the specific rate constants, $k_{12}$ and $k_{21}$, and the equilibrium constant K were determined. As a result of this study more accurate and comprehensive analyses of benomyl and MBC can be achieved. (This kinetic study was done in cooperation with Dr. E. A. Cherniak, Brock University.)

High pressure liquid chromatography is being investigated as a means of determining residues of benomyl and MBC in plant extracts. Results to date suggests that both compounds can be quantified without prior cleanup.

4. Coats, J. R. - Evaluation of the toxicity, degradability, and bioaccumulation potential of pyrethroid insecticides.

Four promising pyrethroid insecticides, permethrin, cypermethrin, fenvalerate, and fenpropanate, were investigated regarding environmental fate and effects. Non-target toxicity was studied for eight species of coccinellids and aquatic invertebrates; cypermethrin appeared to be the least selective pyrethroid. Photodegradation studies were carried out by applying films to glass and exposing to ultraviolet light (254 nm) and by spraying formulations on tobacco plants maintained in a plant growth room. Several pyrethroids showed considerable photostability. Bioaccumulation was assessed through construction of laboratory food chains. Three terrestrial food chains produced no dramatic bioaccumulation for any of the 4 pyrethroids, nor for DDT which was tested as a standard. Aquatic food chain bioaccumulation studies are currently in progress. Very low water solubilities and high partition coefficients indicate the pyrethroids could possibly bioaccumulate through aquatic food chains, depending on degradability of the compounds. Sampling arthropods in permethrin-treated experimental plots (vegetable, orchard, turf) yielded measurable residues in numerous species.

5. Dodson, J. J. and Mayfield, C. I. - The effects of sublethal doses of diquat, simazine, glyphosate and 2,4-D butoxyethanol ester on the rheotropic response of rainbow trout.

An important aspect of the behavioral ecology of fish is their reaction to water currents (rheotropism) and the role of this response in a variety of behavioral mechanisms including migratory orientation (Dodson and Young, 1977). The purpose of the present study was to investigate if the response of rainbow trout to a simulated water current was subject to alteration following short exposure to concentrations of aquatic herbicides similar to their actual field application rates.

The aquatic herbicides used in these tests were as follows: (a) diquat (technical grade) and Reglone A, its commercial formulation (Ciba-Geigy); (b) simazine (technical grade) and Princep 80W, its commercial formulation (Chipman Chemicals); (c) glyphosate (technical grade) and Roundup, its commercial formulation (Monsanto); (d) 2,4-D butoxyethanol ester (technical grade) and Aqua-Kleen, its commercial formulation (Amchem Products).

Rainbow trout, obtained from a local hatchery, were held under a 16 hour daylength for the duration of the experiments. Groups of 10 fish each were exposed for 24 hours to 3 or 4 sublethal concentrations of each compound equal to its range of field application rates plus clean water. 11 exposures were conducted in 511 liter holding tanks (average load = 3 gm/l) in aerated well water at 15°C under static conditions. Where necessary, 24 hour $LC_{50}$'s were conducted in the same tanks under the same conditions. Water temperature, oxygen concentration and pH was monitored throughout all experiments.

The rheotropic response of trout was observed in an optomotor tank (Dodson and Young, 1977) in which the visual stimuli produced by a fish's displacement in a water current is simulated by moving the background past the fish. All fish were observed singly for 15 minutes in an optomotor tank with the background revolving at a rate equivalent to a water current of 20 cm/sec. Three parameters of the rheotropic response were measured; (a) proportion of total observation time spent swimming into the apparent current (frequency of positive rheotaxis); (b) proportion of time exhibiting no rheotaxis; (c) the actual swimming speeds of the fish.

Rainbow trout exposed to 0.5, 1.5 and 5 p.p.m. of diquat exhibited no alteration in the frequency of positive rheotaxis when compared to the control situation. However, these concentrations resulted in increasing the proportion of time fish spent exhibiting no rheotaxis and decreasing the swimming speeds. Similar results were obtained from fish exposed to the same concentrations (a.i.) of Reglone A.

In order to test simazine, 1 ml of Tween 80 was used to establish solutions of 1, 4 and 12.5 p.p.m. Thus, 2 control groups were observed, one in clean water and the second exposed to Tween 80. When compared to these controls, the treatments resulted in a significant decrease in the frequency of positive rheotaxis, a significant increase in the proportion of time exhibiting no rheotaxis and a significant decrease in swimming speeds. However, fish exposed to the same concentrations (a.i.) of Princep 80W with

no Tween 80 exhibited no alteration of the rheotropic response. Thus the alteration of rheotropism exhibited by simazine-treated fish may have been due to the interaction of simazine and Tween 80.

Rainbow trout exposed to 0.75, 1.6 and 6 p.p.m. of glyphosate and .75, 1.6 and 4 p.p.m. (a.i.) of Roundup did not exhibit any significant variation in the 3 rheotropic parameters. However, trout exposed to 6 p.p.m. (a.i.) of Roundup were comatose. The 24 hour $LC_{50}$ of Roundup was determined to be approximately 7 p.p.m.

Trout exposed to 5, 7, 10 and 11 p.p.m. of 2,4-D butoxyethanol ester exhibited decreased swimming speeds, decreased frequencies of positive rheotaxis and increased levels of no rheotaxis. Above 11 p.p.m., fish became comatose. The 24 hour $LC_{50}$ was determined to be approximately 14.5 p.p.m. Fish exposed to 5, 7, 8 and 9 p.p.m. (a.i.) of Aqua-Kleen exhibited the same alterations in the 3 rheotropic parameters as with 2,4-D butoxyethanol ester. Above 9 p.p.m. (a.i.), fish became comatose. The 24 hour $LC_{50}$ was determined to be approximately 10.5 p.p.m.

Fish samples from all treatments are currently being analyzed for the 'received dose' of the active ingredients so that these may be correlated with applied dose concentrations and with concentrations found in fish from natural waters.

6. Ellis, C. R. - The economic threshold of the cereal leaf beetle, Oulema melanopus (L.) on oats and barley in Ontario.

The cereal leaf beetle, CLB, is continuing to spread in Ontario. In 1977, it was found as far east as Quebec and north to within 40 kilometers of Sault Ste. Marie. The pest was present in low numbers however and not economically important. No chemical control was necessary anywhere in Ontario in 1977.

The parasite, Tetrastichus julis, was mainly responsible for the generally small numbers of CLB in Ontario in recent years. In 1977, populations of this parasite were again monitored. There was some concern that the parasite might not keep up with its host, the CLB, as it apread through northern Ontario. An extensive survey in 1977 showed that the parasite was dispering well. Although the fields of oats and barley were scattered and the CLB populations low, the parasite was found in all but two of the fields where the pest was found. Parasitism ranged from 17 to 90% with an average of about 50% parasitism.

There has generally been less than one CLB larvae per 50 sweeps in areas where the pest and parasite have been established for a number of years. This has raised fears that the parasite might disappear and ultimately result in a serious CLB problem. Sampling in Elgin County and Regional Niagara showed that while the host density was low, parasitism in the two areas was 84.7 and 60% respectively and the synchrony between the host and parasite was good.

In conclusion: 1) The parasite is providing adequate control of CLB throughout Ontario and chemical controls should not be required except in rare incidences on isolated fields; 2) The parasite is working effectively at

low CLB densities and no immediate resurgence of the pest is expected; 3) The spread of CLB into northern Ontario has reached the boundary of the quarantine zone and this should now be revised.

7. Fushtey, S. G. - Efficacy of fungicides for the control of snow mold in fine turf grass.

This study has just commenced and will be reported on in 1978-79.

8. Johnson, E. F. and Gardiner, R. P.* - Control of the darksided cutworm, Euxoa messoria (Harris) in southwestern Ontario tobacco fields with permethrin (NRDC 143)

Microplot tests indicated that Permethrin insecticide (3-phenoxybenzyl (±) cis, trans 3-(2,2-dichlorovinyl) - 2,2-dimethyl cyclopropane -1-carboxylate) at 35 and 70 g ai/ha and PP383 (Cypermethrin) insecticide ((±) -d -cyano-m-phenoxybenzyl (±)-cis, trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate) at 17.5 and 35 g ai/ha gave excellent control of Euxoa messoria (Harris) when applied to both rye and wheat cover-crops. Good control of Euxoa messoria was obtained when the rye and wheat covercrops were treated with chlorpyrifos (0,0-diethyl 0-(3,5,6-trichloro-2-pyridyl)phosphorothioate) at 560 g ai/ha. Feeding hole counts indicate that all treatment effectively controlled cutworms.

When applied to soil preplant, chlorpyrifos insecticide at 2240 g ai/ha gave excellent control of darksided cutworm. Permethrin at 70 and 140 g ai/ha and PP 383 at 17.5 and 35 g ai/ha gave good control of cutworm larvae. Feeding hole counts indicate that all treatments effectively controlled cutworms.

Permethrin at 70 and 100 g ai/ha, PP 383 at 17.5 and 35 g ai/ha and Chlorpyrifos at 560 g ai/ha when applied to tobacco seedlings just after transplanting were all effective materials against darksided cutworm. Feeding damage was drastically reduced due to chemical treatment of plants.

9. Gillespie, T. J., Dzikowski, P. A., and Sutton, J.C. - Reduction of fungicide usage on vegetable crops by timing fungicide applications according to weather data.

Plots of carrots and onions were established at the Muck Research Station in the Holland Marsh during 1977 and given various fungicide spray-timing treatments. For both crops no-spray data were obtained, a regular 10-day spray was applied to some plots (beginning July 4 on onions, August 9 on carrots) and weather-timed sprays were applied to other plots before infection periods (beginning after 1-2% disease observed in the crop). Also a systemic fungicide was applied after infection periods on carrots, and a later starting criterion (2-3% disease) was tested in onions.

* Deceased

Table 1. Fungicide timing trials on carrots in 1977.

| Program | Starting % Disease | No. of Sprays | % Disease Sept. 29 | | Yield* (Tonnes/ha) |
|---|---|---|---|---|---|
| | | | Upper Leaves | Middle Leaves | |
| No-spray | --- | 0 | 12 | 20 | 76.3 |
| Regular** | 1.3 | 5 | 2 | 8 | 77.0 |
| Weather-timed** | 1.4 | 4 | 7 | 8 | 74.6 |
| Systemic*** | 2.9 | 3 | 6 | 9 | 73.6 |

* Hand-harvested
** Bravo 6F
*** Bay Meb 6447

During August and September of 1977, precipitation was respectively 150% and 200% of normal and under such wet conditions the weather-timed schedule was little different from the regular program. No significant differences were found in hand-harvested yields but some losses would be expected with a mechanical harvester in the no-spray plots, considering their significantly higher disease levels. The systemic spray was an effective "emergency procedure" to control disease after an infection period occurred on an unprotected crop.

Table 2. Fungicide timing trials on onions in 1977.

| Program | Starting % Disease | No. of Sprays | % Disease on Sept. 12 | Yields | |
|---|---|---|---|---|---|
| | | | | 50 lb bags/acre | Tonnes/ha |
| No-spray | --- | 0 | 45 | 616 | 34.5 |
| Regular | 1.5 | 7 | 8 | 679 | 38.0 |
| Early-timed | 1.6 | 5 | 5 | 694 | 38.9 |
| Late-timed | 2.5 | 3 | 9 | 638 | 35.7 |

* Bravo 6F

Despite wetter than normal conditions, the early-timed onion schedule saved two sprays and had slightly (but not significantly) higher yields than the regular program. A later start for the spray program, or no sprays, resulted in lower yields.

10. Helson, B. V. and Surgeoner, G. A. - Research on control of biting flies, especially mosquitoes, in Ontario.

The susceptibility of Culex pipiens and other mosquitoes to temephos.

The susceptibility of southwestern Ontario populations of Culex pipiens and other important mosquito species to temephos was determined to establish comparative baselines for future monitoring of potential insecticide resistance. The mean LC50 (insecticide concentration lethal to 50% of the larvae) derived by probit analysis was 0.95 parts per billion (ppb) for natural populations of Culex pipiens and 1.1 ppb in a preliminary test with a laboratory colony. These values are similar to those reported in other studies from various parts of the world. The mean LC90/LC50 ratio was less than 2 for the Ontario populations indicating that they were homogeneously susceptible to temephos. The LC50 values for Culex restuans, Aedes vexans and 3 spring Aedes species were 1.2 ppb, 3.0 ppb and 4.0-4.9 ppb respectively.

Evaluation of several insecticides as mosquito adulticides.

Phenthoate, permethrin, CG18809 and a new formulation of propoxur, Baygon® 2, were evaluated as adulticides against Culex pipiens using a LECO® SD ultra low volume aerosol generator. Permethrin (25 g ai/ha) and phenthoate (70 g ai/ha) provided excellent control. Permethrin (12.5 g ai/ha), phenthoate (35 g ai/ha) and CG18809 (15 g ai/ha) provided marginal control. Baygon® 2(25 g ai/ha or 12.5 g ai/ha) generally did not provide satisfactory control but formulation problems are suspected. The LECO® SD, once broken in, was a reliable machine which performed to specifications.

The efficacy of methoprene against Culex pipiens.

Methoprene (Altosid® SR10) is presently registered for the control of floodwater mosquitoes but not Culex species. Because of its safety and specificity, studies were begun in 1977 to determine the feasibility of using methoprene for Culex control.

A charcoal briquet formulation has been designed for the control of all type of mosquitoes including Culex in small breeding sites. This formulation was compared with 2 others in simulated pools against Culex at a dosage of 430 g ai/ha, the rate recommended for the briquet formulation. The effectiveness and residual activity of the SR10 and the briquet formulations were very similar with 90% overall pupal mortality being maintained for 22 and 23 days respectively. The SR10 formulation is 3-4 times less expensive than briquets. A granular formulation was much inferior to the other two.

Altosid® SR10 was also evaluated at rates of 30, 60, 120, 240 and 480 g ai/ha in simulated pools against Culex pipiens. 90% overall mortality was maintained for about 6 days at 30 g ai/ha and about 15 days at 480 g ai/ha. At the intermediate dosages this mortality level was maintained for about 7-11 days. A dosage of Altosid® SR10 as low as 60 g ai/ha would probably provide satisfactory control of Culex in transient pools and in continuously breeding sites if reapplied at weekly intervals.

In 2 natural pools, Altosid® briquets at the recommended rate provided 90% control of C. pipiens for as much as 6 weeks but only within a short distance of the briquet. Mortality was greatly reduced at distances of 3-6 m from the briquets.

The usefulness of the insect growth regulator, Dimilin® for mosquito control in Ontario. A 1% granular formulation of Dimilin® was tested against larvae of the Aedes stimulans group and A. vexans in 4 natural pools at a dosage of 44.8 g ai/ha. The mean population reductions for all sampling methods were 98.1, 99.9 and 97.9% in 3 pools 6-10 days after treatment. Similar reductions occurred in the fourth pool but corresponding reductions were also noted in the control pool. Certain non-target invertebrates (Cladocera, Ostracoda, Copepoda, Trichoptera larvae, Chironomidae larvae) were adversely affected by the treatments in 2 pools analysed to date. Other invertebrates (Amphipoda, Coleoptera adults and larvae, Hydracarina mites)were evidently not affected.

In simulated pools, 100% mortality of Culex pipiens larvae exposed immediately after treatment was obtained with both the 1% granular and a 25% wettable powder formulation. No residual action was evident with either formulation when larvae were exposed 4 or 7 days after treatment. Dimilin® is an excellent mosquito larvicide under Ontario conditions.

The effectiveness of several insecticides as mosquito larvicides (and/or pupicides) in Ontario. A 2% granular formulation of phenthoate was evaluated as a mosquito larvicide against Aedes species at a dosage of 70 g ai/ha. In 4 natural pools mean mortalities for all sampling methods ranged from 20.5-96.6%. Although the control achieved was sometimes very good, it was too variable for phenthoate at this dosage to be considered for use under Ontario conditions.

The petroleum oil, Flit®MLO was applied to 2 natural pools at a rate of 28 l/ha to further evaluate its effectiveness as a pupicide against spring Aedes mosquitoes at cool water temperatures. Pupal reductions of 96% occurred at water temperatures ranging from 4°C to 20°C with a mean of 11°C during the 2-day period after treatment. Flit® also effectively controlled the remaining larvae in these pools. Effects on non-target invertebrates are currently being assessed.

Dursban® 10CR and Ecopro-17, controlled release formulations of chlorpyrifos and temephos repsectively designed to give season long mosquito control with one application, were evaluated at the manufacturers' recommended dosages in simulated pools against C. pipiens. Dursban® 10CR at 1.48 g ai/1000 l. water usually provided 85-100% control of 3rd and 4th instar larvae until the experiment was terminated 64 days after treatment. Ecopro-17 at 504 g ai/ha was ineffective under these conditions.

Field evaluation of insect electrocutors for mosquito control in southern Ontario. The mean number of spring Aedes mosquitoes biting in backyards with electrocutors was 30.7, whereas the mean number in nearby control yards was 22.7. When tested against Aedes vexans and Mansonia perturbans the mean number biting in yards with electrocutors was 22.7, whereas the mean number in adjacent yards was 30.6. These means are not statistically different. Female mosquitoes killed in electrocutors represented 17-24% of total numbers recorded in the yards. Female mosquitoes represented 0.4-4.1% of the total insects killed by electrocutors. These devices do not provide appreciable protection from mosquito bites.

Seasonal abundance, biting and egg laying activity of Coquillettidia perturbans in southern Ontario. Three sites were monitored by dry ice-baited CDC light traps and biting counts to evaluate the nuisance status and optimal time for adulticing of C. perturbans. A mean of 2203 mosquitoes per night were trapped at weekly intervals from June 10 to September 21 in Leamington and St. Catharines. A maximum of 18,604 was collected on July 12. Few were collected in Guelph. During the dusk activity period a mean of 66 mosquitoes per hour were taken in biting collections with a maximum of 408/hr. 85% of the activity occurred during the first hour after sunset. Maximum activity occurred approximately 30 minutes after sunset.

Egg-raft sampling was used to locate possible larval breeding habitats and to determine the duration of the egg laying period. Egg-rafts were collected from June 30 to Sept. 8 with most being laid from mid-July to mid-August.

11. Inculet, I. I., Castle, G. S. P., and Kelly, C. B. Electrostatic application of pesticides in orchard and field crops.

Over a 5-year period a full scale electrostatic orchard sprayer has been designed, modified and field tested to the stage where it can be considered by equipment manufacturers.

The sprayer has been designed to work in conjunction with a Kinkelder commercial sprayer. The special equipment consists primarily of an insulated liquid reservoir electrified from a high voltage power supply. The liquid spray is pressurized and fed through insulated plastic tubing to an array of standard Kinkelder air-shear nozzles mounted in a pair of fibreglass shrouds having the same throat geometry as the standard units.

The 1977 field test of 100 trees in a large commercial orchard in southwest Ontario indicated an improved leaf coverage by spray materials from using the electrostatic sprayer and fruit quality was maintained with a 30% reduction in spray materials.

12. Kaushik, N. K. - Effects of insect growth regulators on emergence of black fly larvae and on non-target aquatic invertebrates.

This study will be reported on in 1978-79.

13. Laing, J. E. - Development of monitoring techniques for the apple maggot.

In an attempt to identify an attractant for the apple maggot, eleven chemicals synthesized by Dr. C. C. Leznoff, of York University, were tested at two concentrations in both yellow and white Pherocon insect traps. Unbaited traps and traps baited with protein hydrolysate served as controls. The traps were placed in an orchard located at the University of Guelph. This orchard has a history of heavy apple maggot infestation and provides an ideal test site for potential maggot attractants. Of the chemicals tested, two showed some attractancy to the apple maggot adults. Further tests on these two chemicals are being conducted using an olfactometer. All of the chemicals tested in the

field are presently being run through electro-antennograms by Dr. W. L. Roelofs at the New York State Agricultural Experiment Station, Geneva. The results of these antennograms, along with our field and olfactometer data, may enable us to narrow the search for a likely maggot attractant.

Information on the time of emergence of adult male and female apple maggots, the condition of the ovaries of the adult females attracted to the various types of traps and the timing of the exit of the maggot larvae from the apples has been accumulated during this study.

One of the chemicals tested for the apple maggot showed considerable attractiveness to another pest of apples, the spotted tentiform leafminer, Lithocolletis blancardella Fabricius. This chemical is considerably different in structure to one identified during 1977 by Roelofs et al. as the sex attractant for the spotted tentiform leafminer (Roelofs, W. L., W. H. Reissig and R. W. Weires. 1977. Sex attractant for the spotted tentiform leafminer moth, Lithocolletis blancardella. Environ. Entomol. 6:373-74). In a subsequent personal communication, Roelofs indicated that the species of leafminer for which they have identified the sex attractant may not be the spotted tentiform leafminer L. blancardella, but a closely related species L. crataegella Clemens. We have sent our compound and the species of leafminer which occurs in this area to Roelofs for testing on the electro-antennogram. We expect to conduct further field tests on L. blancardella of both Roelofs' attractant and our compound during the 1978 flight periods.

14. Leznoff, C. C. and Svirskaya, P.I. - The chemical synthesis of candidate sex attractants for the apple maggot.

In the summer of 1976, a series of 9 carbon chain cis and trans-olefinic alcohols, aldehydes, and esters were synthesized as candidate sex attractants for the apple maggot by the solid phase method (C. C. Leznoff, T. M. Fyles, and J. Weatherston, Can. J. Chem. 54, 1143-1153 (1977). Field testing was carried out in cooperation with Dr. J. Laing of the University of Guelph. As a result of this initial screening, a series of 8, 9, 10, 11 and 12 carbon chain trans-olefinic alcohols (listed below) were synthesized by the solid phase method.

$$CH_3(CH)_{2m}\ CH{=}CH{-}(CH_2)_nX$$

trans or cis

1. trans m = 1, n = 4, X = OH
2. " m = 2, n = 4, X = OH
3. " m = 1, n = 5, X = OH
4. " m = 4, n = 3, X = OH

4A. " m = 4, n = 3, X = OAc

5 " m = 3, n = 4, X = OH

6. trans m = 2, n = 5, X = OH

7. " m = 1, n = 6, X = OH

8. " m = 5, n = 3, X = OH

9. cis m = 2, n = 5, X = OH

10. " m = 4, n = 3, X = OH

10A. " m = 4, n = 3, X = OAc

11. trans m = 0, n = 9, X = OH

11A. " m = 0, n = 9, X - OAc

Field-testing studies on 1-11 in the summer of 1977 showed that compound 4 was attractive to apple maggot but that equal numbers of males and females were caught. Thus, although an attractant has been found, the sex attractant still has not been found. It is felt that the specificity of compound 4 for apple maggots narrow the candidates likely to be sex attractants.

It was also found that compound 6 was exceedingly attractant to the spotted tentiform leaf miner, Lithocolletis blancardella. This serendipitous discovery is particularly important for determining moth emergence and flight periods more precisely for use in management and control of this pest.

15. Mayfield, C. I. - Herbicide residues in organic soils following the use of linuron and chlorobromuron.

The herbicides were applied at field application rates and five times the field application rates to quadruplicate 1 sq. meter plots of organic soil from the Grand Bend area in southwestern Ontario. Initial samples of the soil were removed from specific areas of the plots using a grid sampling pattern. At intervals during a two-year period further samples were removed from each of the plots. The usual sampling interval was 1 month. The soils were analyzed for their linuron and chlorbromuron content using two separate procedures; the first involved extraction and conversion to the respective dichloroaniline derivative which was then applied to a Carbowax 20 M plus Chromosorb W/AW DMCS gas chromatographic column. The derivatives were detected by flame ionization. The second method involved direct detection of the herbicides by electron capture after extraction and dehydration. The column was a 5%E-301 on Gas Chrom Q (60/80 mesh).

Both linuron and chlorbromuron were undetectable after 2 years when applied at the normal field application rates. Significant residues were detected after one full year, especially when the 5X FAR plots were examined. After 2 years slight residues of both herbicides were found in these 5X FAR plots.

Decomposition products of the herbicides were not detected in any of the soil samples examined.

Laboratory experiments at different incubation temperatures demonstrated that both herbicides were degraded only very slowly at 4C and that the rate of degradation increased with increasing temperature up to 20C.

Tests with a sand loam soil showed that the herbicides were degraded at a significantly higher rate than in the organic soils.

Studies on the rate of degradation at various depths in the organic soil showed that the most rapid degradation occurred in the top 5 cm.

16. McEwen, F. L., Harris, C. R., Ritcey, G., McGraw, R., Caldwell, E., Sawinski, T., Aspinall, D. - Control of the onion maggot, Hylemya antiqua Meigen by use of the sterile male technique.

Field experiments in 1977 involved the release of insects sterilized by each of two methods, irradiation and chemosterilants.

In the irradiation tests, pupae were irradiated at 4K rads from a $Cobalt^{60}$ source and 500,000 were released against the second generation adults in 3 weekly releases. The first release was by ground distribution of pupae but in the 2nd and 3rd releases, an aircraft was employed. Pupae were released on a 50 acre onion field with a spring pupal count of 2.8 per square yard. Recapture of adults indicated a ratio of 0.1 to 1.1 with respect to released versus wild flies during the 4 week period after the initial release and egg hatch ranged from 59 to 83%. Since normal egg hatch is about 90%, the reduction obtained was significant and was as good as could be expected based on the ratio of wild to released flies in recapture traps. No adulticides were applied after the releases were begun and maggot damage was insignificant.

In a separate experiment 1,205,000 adult flies were fed the chemosterilant Hempa and released on two farms. On one farm releases were made weekly beginning May 16 and continued for 21 weeks, while on the other farm releases were made against the first generation only. Egg hatch was monitored throughout the season and in addition, released flies were tagged so that they could be identified upon recapture. Despite the fact that the number of flies released was calculated to provide a high flooding ratio of released to wild flies, this did not occur, and the mean ratio during the release period was 0.31 released to 1.0 wild. The percentage reduction in egg hatch was only 9% and was disappointing in view of the 20% reduction achieved in 1976. The reason for the poor results seems associated with poor survival of released flies in the field. In general few released flies were recaptured after 10 days and most recoveries were within 6 days of release.

The effect of the releases on field control as assessed by maggot damage suggests that the method of determining effectiveness on a "percentage egg hatch" basis underestimates the effect on larval populations. Where releases were employed in 1977 significant maggot damage did not occur, control being as good as where chemical adulticides were applied.

The food source of adult onion maggots was studied in the laboratory and field. In the field flies were observed feeding on dandelion and strawberry blossoms and on damaged onions. In the laboratory a freeze-dried algal preparation provided a good food source. Tests for enzymes in the digestive tract of the fly indicate that amylase is not present. This suggests that starches are not important food sources. Chymotrypsin was not found and only small amounts of trypsin. This suggests that rather than a protein, the source of amino acids for the adult may be a peptide. Identification of the natural food source would be an important step in a control procedure using chemosterilants since these could be incorporated in a bait for field use.

Studies on temperature requirements for onion maggot development were continued. Using a threshold temperature of 10°C it was demonstrated by two methods that "day degree accumulations" can be used to predict adult emergence with a minimum or error. This will reduce the amount of monitoring needed to recommend the timing of adulticide sprays to coincide with peak populations and hence reduce the number of sprays required.

17. Miles, J. R. W. - Accumulation of residues of carbamate insecticides in organic soils in Ontario.

Insecticides applied with the seed as "furrow" treatments are present in the region of the plants in much greater concentration than when applied as broadcast treatments. Very little information is available on these actual soil concentrations. In 1977 we sampled directly in the rows for soils treated with ethion, fonofos and carbofuran to control onion maggot on onions and with carbofuran to control carrot rust fly on carrots. These soil samples were analysed to measure the concentration and persistence of ethion, fonofos and carbofuran during the growing season. Initial concentrations of ethion in soil were 47 ppm (Keswick) and 128 ppp (Thedford) with 51% and 25% of initial residue remaining in September. Initial fonofos concentrations were 82 and 93 ppm with 13% and 25% of initial remaining in late August. Initial soil residues of carbofuran ranged from 36 to 155 ppm with 0 to 3% remaining in late August-early September. Therefore ethion appears to be somewhat more persistent than fonofos in muck soil while carbofuran disappeared completely during the growing season. Analysis of dry onions, onion sets and carrots at harvest showed no detectable residues of ethion, fonofos or carbofuran. Canning onions (Thedford) contained 0.12 ppm ethion at harvest and 0.07 ppm ethion in the factory cleaned onions.

Twenty-one farm soils were sampled in the fall of 1977 for determination of residues of carbofuran and/or carbaryl. All farms had a history of treatment with these insecticides. Residues are being determined by gas chromatography.

18. Stopps, G. J., Brown, J. R.,* Alcock V. - Neuro-muscular function in persons exposed to organophosphorous pesticides compared with an unexposed control group.

Previous studies in Europe have shown that workers engaged in organophosphorous pesticide manufacture may have slower conduction of the nerve impulse as measured in some of the major nerves of the arm, than non-exposed control groups. The present study was designed to compare the

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speed of conduction of the nerve impulse in applicators of organophosphorous insecticides with a control group of persons not exposed to such insecticides. Two groups of applicators are being studied, those in the Holland Marsh area and pest control operators in Metropolitan Toronto.

Because of delays in the delivery of the equipment and the need to develop techniques that would allow measurements to be made in non-laboratory situations progress in the study has been slower than expected but by the time of the presentation it is anticipated that eighteen control and eighteen exposed subjects will have had measurements made.

The first group of applicators to be examined are pest control operators. Measurements of applicators in the Holland Marsh area are expected to start in mid February.

19. Tomlin, A. D. and Broadbent, A. B. - Feasibility of using the litterbag technique as an index of the environmental impact of soil insecticides on soil fauna.

Nylon fabric bags (10 x 10 cm) of three mesh sizes, 5, 710 and 9,000 µm, which exclude soil invertebrates of different size-classes, were filled with a known area of leaf tissue. Following burial in the spring the bags were unearthed at various times throughout the summer and autumn to measure the remaining leaf area, and litter decomposition rates were determined.

In the first experiment, 3 agricultural systems were studied: corn field, pasture, and orchard. The cornfield was studied using both carbofuran row-treated, and untreated plots. A significant decrease in the decomposition rate of corn leaves was noted in the carbofuran treated plots with the large mesh bags. Corn leaves decomposed faster in the cornfield system than corn leaves in the pasture or orchard system. Baseline decomposition rates were also determined for maple and apple leaves in pasture and orchard respectively.

Carbofuran soil residues dropped below 1 ppm by the twelfth week following treatment in the cornfield. Other insecticide residue levels, generally low except for t-DDT, were determined (including arsenic in the orchard). Soil type and soil pH were also determined. Soil cores taken 4 weeks after carbofuran treatment in the cornfield showed no significant decline in soil arthropod populations except for Isotomidae (Collembola) compared to the untreated control. Five months after carbofuran treatment, there was no significant decrease in numbers or biomass of earthworms when compared to untreated control plots.

A second experiment, started in the autumn of 1977, is designed to establish baseline decomposition rates for a variety of tree leaf species (corn, silver maple, apple, and beech) in the soil for 2 different systems: pasture and deciduous woodland. The succession of decomposer animals is also being studied.

20. Tu, C. M. - Effects of pyrethroid insecticides on microbial populations and activities in soil.

Several very effective pyrethroid insecticides are being tested for control of many species of insects. Problems experienced with pesticides in the past have clearly demonstrated the need for assessment of the potential which an insecticide may possess to cause unacceptable side effects. Tests were conducted to determine the effects of cypermethrin (WL 43467), fenvalerate (WL 43775), permethrin (NRDC 143), NRDC-161 ((S)-α-cyano-3-phenoxybenzyl (IR. cis)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylate), and WL 41706 ((R,S)-2- cyano-3-phenoxybenzyl 2,2,3,3-tetramethylcyclopropane-carboxylate) at 0.5 and 5 µg/g AI on microbial populations and activites in a sandy loam. All insecticides affected bacterial and fungal populations during the first week of incubation, but populations subsequently recovered. A stimulatory effect was apparent on nitrification in some instances. Oxygen consumption indicated that soil microbial respiration increased in proportion to the concentration of insecticides, suggesting the possibility of microbial degradation of the insecticides in soil. None of the insecticides inhibited non-symbiotic nitrogen fixation or urease activity. However, fenvalerate and NRDC-161 stimulated dehydrogenase activity in soil.

21.* Svec, H. J., Chapman, R. A., and Harris, C. R. - Control of cutworms attacking agricultural crops in Ontario.

Several species of cutworm, especially the darksided, redbacked, black, and variegated cutworms, periodically cause serious damage to agricultural crops in Ontario. Organochlorine insecticides were effective but can no longer be used for this purpose. An intensive research effort in the late 1960's and early 1970's involving Agriculture Canada, the Ontario Ministry of Agriculture and Food, the Ontario Pesticides Advisory Committe, and the Agricultural Chemicals Industry resulted in registration of chlor-pyrifos and leptophos for cutworm control. The former was registered for a limited number of uses, the latter for use on a wide range of vegetable and field crops. In 1977 the use of leptophos was banned leaving only one effective insecticide available for use on a limited number of crops. The objective of this study was to determine under the laboratory and field conditions if any of the current experimental insecticides show potential for cutworm control.

In earlier work referred to above over 150 experimental insecticides were screened at the London Research Institute for activity against cutworms. Less than 20 were toxic to cutworms and effective in soil. Several gave good results in subsequent field tests but of these only two were registered for use. Since then only a few experimental compounds have become available for evaluation. However, of 14 insecticides tested in the laboratory for contact toxicity to darksided cutworm larvae, 5 (all pyrethroids) showed excellent activity. Subsequent tests indicated that the pyrehtroids were highly toxic, not only to the darksided cutworm, but also to the black, white and variegated cutworms. Other laboratory tests indicated that the pyrethroids were quite strongly inactivated when incorporated into soil, but were remarkably toxic to cutworms as soil surface applications. Two other experimental insecticides, formulated as baits also showed promise for cutworm control.

* Funded in 1976-77.

Field tests were conducted with two goals: 1) to obtain data enabling more comprehensive registration of chlorpyrifos for cutworm control; and 2) to assess the efficacy and persistence of the pyrethroid insecticides. In the earlier work referred to above much of the data on efficacy and persistence of chlorpyrifos was obtained. However, registration of chlorpyrifos as a postplanting treatment for cutworm control on vegetable crops had not been requested by the company concerned. An application was submitted and approved in 1977. To allay concern that postplanting treatments of chlorpyrifos would be phytotoxic microplot tests were conducted using cucumbers and peppers as indicator plants. Neither EC nor WP formulations of chlorpyrifos were phytotoxic. In microplot field tests the pyrethroid insecticides available for field evaluation provided excellent control as pre- or postplanting treatments at rates of 70-140 g. AI/ha (1-2 oz/acre) as compared to 560-1120 g. AI/ha (8-16 oz/acre) of chlorpyrifos, of darksided, white, and black cutworms attacking tobacco, asparagus, and onions grown on muck soil respectively. At 70 g AI/ha (1 oz/acre) they suppressed variegated cutworm attacking tomatoes, but did not give completely satisfactory control. None of the pyrethroid treatments were phytotoxic.

Methods for extraction, cleanup, and analysis of pyrethroid residues in soils and some crops were devised. Crop samples collected from plots used for efficacy studies are currently being analyzed for residues.

APPENDIX IV. Publications, theses, and papers submitted to scientific conferences relating to the Ontario Pesticides Advisory Committee Research Programs, April 1, 1977 - March 31, 1978.

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Chiba, M. and Cherniak, E. A. 1978 Kinetic studies of reversible conversion of benomyl to MBC and n-butyl isocyanate in organic solvents. J. Agric. Food Chem. In Press.

Gillespie, T. J. and Kidd, G. E. 1978. Sensing duration of leaf moisture retention using electrical impedance grids. Can. J. Plant Sci. In Press.

Harris, C. R. and Kinoshita, G. B. 1977. Influence of post treatment temperatures on the toxicity of pyrethroid insecticides. Journal of Economic Entomology. 70: 215-218.

Kinoshita, G. B., Harris, C. R., Svec, H. J. and McEwen, F. L. 1978. Laboratory and field studies on the chemical control of the crucifer flea beetle Phyllotreta cruciferae (Goeze)(Coleoptera: Chrysomelidae on cruciferous crops in Ontario. Canadian Entomologist. In Press.

Helson, B. V., Surgeoner, G. A., Wright, R. E., and Allan, S. A. 1978. Culex tarsalis, Aedes sollicitans, Aedes grossbecki: New distribution records for southwestern Ontario. Mosquito News. 38: 137-138.

Langenberg, W. J., Sutton, J. C., and Gillespie, T. J. 1977. Relation of weather variables and periodicities of airborne spores of Alternaria dauci. Phytopathology 67: 879-883.

Miles, J. R. W., Harris, C. R., and Moy, P. 1978. Insecticide residues in organic soils of the Holland Marsh, Ontario, Canada, 1972-75. Journal of Economic Entomology 71: 97-101.

Miles, J. R. W. and Harris, C. R. 1978. Insecticide residues in water, sediment, and fish of the drainage system of the Holland Marsh, Ontario, Canada, 1972-75. Journal of Economic Entomology 71: 125-131.

Reid, J. A. K. and Laing, J. E. 1978. Developmental thresholds and degree days to adult emergence for overwintering pupae of the apple maggot, Rhagoletis pomonella (Walsh) collected in Ontario. Proc. Ent. Soc. Ont. 107: 17-21.

Sharom, M. S. 1978. The behaviour and occurrence of some insecticides in aquatic systems. Ph.D. thesis presented to the Faculty of Graduate Studies, University of Guelph.

Ship, J. L. and Wright, R. E. 1978. A new northern limit for the distribution of Orthopodomyia signifera. Mosquito News. In Press.